

- The digestive system
- Enzymes

Different sized particles

Each nutrient in our food is made up of particles. Carbohydrates, fats and proteins are all made of large particles. Vitamins and minerals are made of small ones. These particles are called molecules. You will learn more about **molecules** in Unit E Atoms and molecules.

The long journey

When you chew up and swallow your food, it begins its journey through a long tube from the mouth to the anus. The tube is called the **gut** and it is nine metres long.

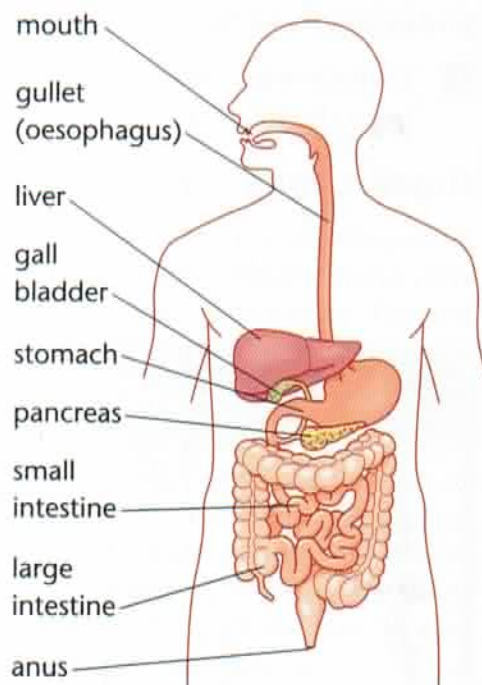
Food contains nutrients. Carbohydrates, fats and proteins are all large molecules. To get these nutrients into our bodies, these large molecules must be broken down into smaller molecules. This is a **chemical process** called **digestion**.

The **digestive system** includes all the organs that take part in digestion. They are shown in the diagram on the right.

The first part of the gut is called the **gullet** or **oesophagus**.

In the **stomach** the food is churned up for a while by its muscular walls. After a few hours the food has become a runny liquid. This leaves the stomach and enters a long tube called the **small intestine**.

As the food passes through the digestive system it is mixed with **digestive juices** that help to break down the different nutrients.



Breaking it down

The digestive juices contain chemicals called **enzymes**. These help to break the larger molecules into smaller molecules. Enzymes make the digestion of food happen more quickly. Enzymes for digesting food are found in the mouth, stomach and small intestine.

- a** Why do you think it is important for food to be digested quickly?

Each enzyme speeds up the breakdown of a different type of nutrient. Some break down carbohydrates, some break down proteins and others break down fats.

Did you know?

Some washing powders are described as 'biological', and others are 'non-biological'. **Biological washing powders** contain enzymes that help to clean dirty clothes. They break down stains caused by proteins in foods such as egg or gravy.

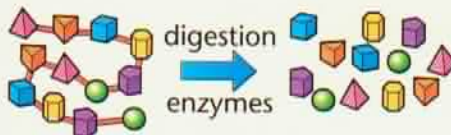
getting smaller →

starch (carbohydrate) → glucose



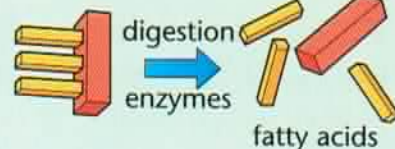
getting smaller →

protein → amino acids



getting smaller →

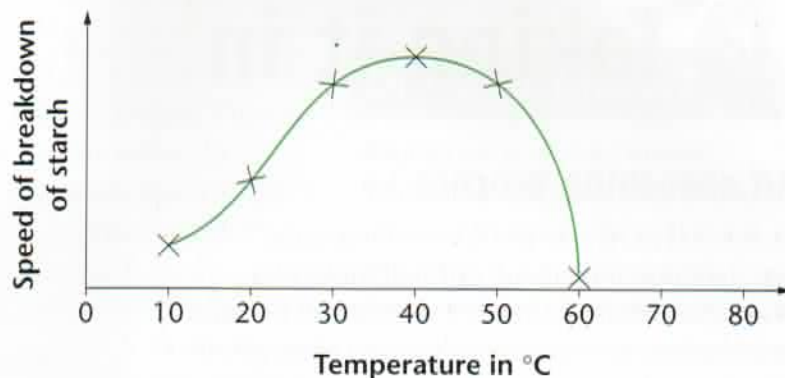
fat → glycerol and fatty acids



The right conditions

Each enzyme needs particular conditions to work. Saliva in the mouth contains an enzyme called **amylase** that helps to break down starch. Amylase works best at pH 7. It stops working in the stomach because the digestive juice there contains hydrochloric acid. Here the pH is low, which is best for the enzyme in the stomach that acts on proteins.

As well as pH conditions, enzymes also have particular temperatures at which they work best. Matt and Alison set up an experiment to find out the best temperature for amylase. The graph above shows their results.



- B** (i) At which temperature does the breakdown of starch take place in the shortest time?
 (ii) Is there a relationship between how well amylase works and body temperature?
 (iii) What do you think might have happened if the experiment had been carried out at 70°C or 0°C?

Did you know?

If you leave bread out, fungi will start to grow in it and turn it mouldy. Fungi secrete enzymes onto the bread to digest it. Then they can take in the smaller molecules. The bread becomes very slimy.

Beaumont's experiment



In 1922 a particularly interesting experiment started to find out what happens in the stomach. An American army porter called Alexis St Martin was accidentally shot in the stomach. The hole never healed properly, but a flap of skin grew over it.

Dr William Beaumont sampled the stomach contents through this flap. He tied a piece of meat to the end of a silk string, dangled it through the hole into St Martin's stomach and pulled it out a couple of hours later to see if it had been digested.

In one of Beaumont's experiments, St Martin ate a meal of bread, beef, potatoes and turnips. Beaumont sampled the contents of his stomach over a period of three hours. He found that the meat was digested faster than the vegetables.

- C** (i) Which nutrient was digested most quickly in the stomach?
 (ii) Which nutrient is meat mainly made out of?
 (iii) What can you conclude about the digestive juice in the stomach from Beaumont's experiment?

Questions

- Design a poster to show what happens when food is broken down. Include the role of enzymes.
- Milly says scurvy is caused by people not having an enzyme to digest vitamin C. Do you agree with her? Explain your answer.
- Do you think Beaumont's experiment would be allowed today? Explain your answer.

For your notes:

- **Digestion** takes place in the digestive system.
- Digestion is the breakdown of large food **molecules** into small food molecules.
- **Enzymes** speed up the breakdown of food.
- Different enzymes work on different nutrients.

An absorbing process

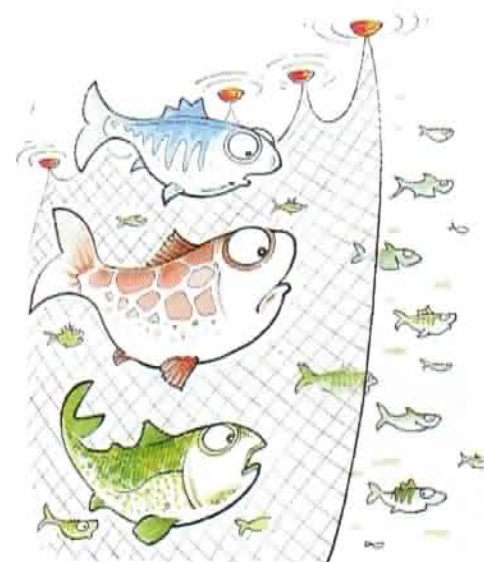
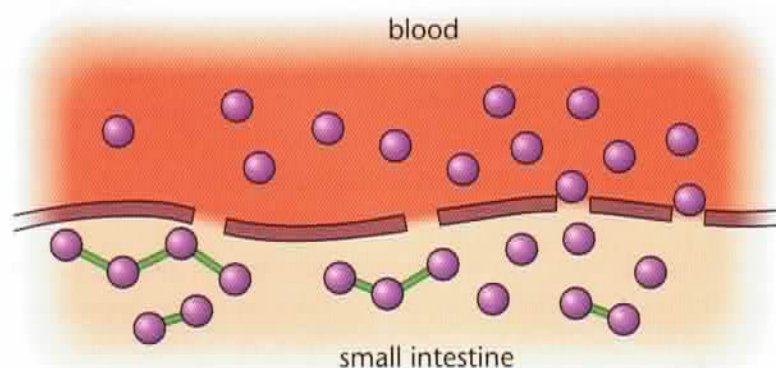
At the end of its stay in the small intestine, digested food is made up of small molecules. These pass through the wall of the small intestine into the blood. This process is called **absorption**. The digested food molecules are taken away in the blood to cells where they are needed.

How do molecules of digested food go through the intestine wall? This is where it counts to be small.

Look at the above diagram. Small molecules such as glucose can pass through the wall of the small intestine. They pass into the blood to be carried away to the parts of the body where they are needed. It's like a sieve. Large starch molecules cannot pass through. They need to be broken down to smaller glucose molecules before they can be absorbed.

Some substances in food, such as minerals and vitamins, are small enough to go straight through the gut wall without being digested. Other substances, such as fibre, cannot be broken down as there are no enzymes to do it.

- a** Look again at the diagram above showing small molecules getting into the blood. Try to think of two ideas you could use as models to explain absorption. This picture of fish will give you a clue for one model.



Villi

Look at this photo. The small intestine has millions of tiny finger-like structures called **villi** (singular **villus**) on its surface. The villi make the surface area of the small intestine much larger. The large surface makes sure that the digested food is absorbed quickly.



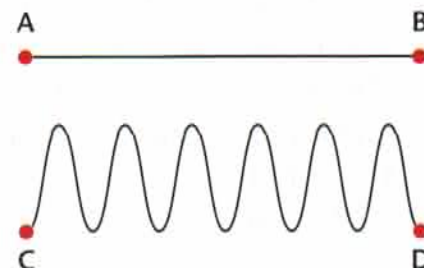
Try this. You will need a piece of cotton or string. Measure the distance in a straight line between points A and B, and between points C and D. Write them down.

Now measure the length of the string joining A and B, and the length of the string joining C and D.

- b** (i) What is the effect of the villi?
(ii) Explain the function of the villi.

Did you know?

There are about five million villi in your small intestine, making a surface area of about 30 m².



Passing through

Some undigested food, mainly fibre, is left in the small intestine. Fibre is made of molecules called **cellulose** that come from plant cell walls. Humans cannot digest cellulose because they cannot make the enzyme **cellulase** that is needed to break it down. Herbivores like rabbits have **bacteria** in their gut that produce cellulase.

In humans, undigested food such as cellulose passes into the **large intestine**. It is stored here, and water is absorbed from it into the blood to be used by the body. Later the waste is pushed out of the body as faeces through the **anus**. This process is called **egestion**.

- C** How are herbivores like rabbits able to digest plants?

Problems ...

If your digestive system is working well, the waste from your food should leave your body after about 36 hours. A lack of fibre in your diet can cause constipation. The faeces are stored for too long. They become dry and hard. The best way to avoid constipation is to include more fibre in your diet – eat plenty of fruit and vegetables.

An infection of the large intestine can cause **diarrhoea**. The waste is not stored for long enough and not enough water is absorbed back into the blood. A person suffering from diarrhoea should drink lots of fluids.



This X-ray shows the large intestine.

Questions

- Write a paragraph to explain absorption using the words below.
glucose molecules small intestine starch villi
- The small intestine is one of the longest parts of the gut. It is folded up inside the body. Why do you think it is so long and folded?
- Explain why vitamins and minerals can pass through the wall of the small intestine but fibre cannot.
- Describe what happens in the large intestine. You could show this as a diagram.
- What causes:
a constipation? **b** diarrhoea?
How can they be prevented?
- Write a poem about the journey of the food through the gut.

Did you know?

Rabbits eat their own **faeces**! When they eat grass, they produce lots of soft faeces. They eat these and digest them again before producing dry rabbit droppings.

Did you know?

Babies can die from diarrhoea because they lose too much water from their body.

For your notes:

- Only small molecules can pass through the wall of the small intestine into the blood.
- Small molecules of digested food are **absorbed** into the blood.